

5-15-01

## STATISTICAL DEMONSTRATION OF COMPLIANCE WITH HWC MACT FEED RATE LIMITS

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### ABSTRACT

Unless a facility chooses to utilize continuous emission monitors (CEMS) to demonstrate compliance with the HWC MACT emission standards for mercury, the semivolatile metals (lead and cadmium), low volatile metals (arsenic, beryllium, chromium), HCl and chlorine, and particulate matter (PM), they will be faced with continuously demonstrating compliance with these standards with constituent feed rate limits. If a facility chooses to pursue the feed rate limit route, which most HWC will do, the HWC rule states in 40 CFR 63.1209(c)(4) that one "must monitor and record feed rates as follows:

- Determine and record the value of the parameter for each feedstream by sampling and analysis or other method
- Determine and record the mass or volume flowrate of each feedstream by a CMS... and
- Calculate and record the mass feed rate of the parameter per unit time."

The rule also states in 40 CFR 1208(b)(8) that "For each feedstream, you must demonstrate that: (i) each analyte is not present above the reported level at the 80% upper confidence limit (UCL) around the mean... Reference is provided to the "Guidance for Data Quality Assessment - Practical Methods for Data Analysis, EPA QA/G-9, January 1998, EPA/600/R-96/084, for deriving these 80% UCL values. So, as part of demonstrating compliance with a constituent feed rate limit, the regulations appear to state that a concentration value must be statistically derived for each MACT constituent (VM, SVM, LVM, Ash, and  $Cl_2/Cl^-$ ) for each feedstream.

In an effort to clarify the regulatory intent of the Rule language, above, Focus Environmental had numerous phone conversations and several rounds of correspondence with EPA Headquarters staff. The result of the discussions was a much clearer understanding of EPA's intent, which is somewhat different from our initial preconception based on reading the regulation. Most of our new understanding of the intent has been confirmed by EPA. (We have suggested minor revisions to the wording of the regulation in one of the technical amendments, but do not believe this will occur.) Despite this clearer understanding, the authors note that implementation of this requirement is not straightforward or well defined. This paper focuses on several important issues that must be addressed associated with evaluating waste feed constituent data, and statistically arriving at the constituent "analyses of record" that will be used to continuously demonstrate compliance with the constituent feed rate limits.

### INTRODUCTION

The regulatory language quoted above for statistically demonstrating compliance with constituent feed rate limits collectively occupies less than two inches of one column of the Federal Register language in the September 30, 1999 HWC MACT final rule. However, the implications of this language to affected hazardous waste combustion facilities are substantial. In addressing these provisions as written, facilities must consider the availability and quality of historic data that is available to statistically derive a representative concentration of each HWC MACT constituent in every feedstream; not just the hazardous waste feed. In this paper we refer to this representative concentration of a MACT constituent as the "analysis of record".

Depending on the requirements of their current RCRA waste analysis plan (WAP), some facilities may not have been required to collect sufficient constituent data and therefore do not have historic data on all of

the HWC MACT constituents. Others may have this data on their hazardous waste feedstreams, but not on the nonhazardous waste feedstreams or supplemental fuel. The quality of the data is also critical, and from the authors' experiences, frequently inadequate. Also, even if proper QA/QC procedures were followed, the analyses may not have provided adequately low detection limits to support key decisions concerning the compliance strategy [i.e. such as the maximum theoretical emission concentration (MTEC) approach in 40 CFR 63.1207(m)(2) and/or the alternative particulate monitoring (PM) approach for incinerators in 40 CFR 63.1206(b)(14)]. (Note that the alternative PM approach is subject to change per the January 2001 technical amendments, which were still unresolved at the time of preparation of this paper). More examples can be given, but the bottom line is that the HWC MACT rule is very prescriptive on the need for HWC facilities to know the levels of the MACT constituents in all streams fed to their combustion systems. They also require these facilities to describe precisely in their Feedstream Analysis Plans (FAP) how they will use these MACT constituent levels in all feedstreams to continuously demonstrate compliance with their respective MACT feed rate permit limits.

This paper provides a basis for evaluating historic data on HWC MACT feedstream constituents and a basis for selection of the approach that a given facility will adopt to demonstrate compliance with HWC MACT feed rate limits. Discussion on establishing a frequency-of-reanalysis basis is also provided. The intent is to provide the reader with a method to wade through the not-so-obvious issues associated with establishing and maintaining these very important MACT constituent levels in each feedstream. Details of QA/QC analytical protocols and statistical methods are not addressed in this paper. Also, the methodology for preparing the FAP from these established constituent levels is not addressed in detail. The many prescriptive facets of these topics warrant a more comprehensive discussion than is possible in this paper, so they are only mentioned to clarify how these activities relate to arriving at the MACT constituent concentrations. Due to the higher complexity and regulatory oversight of commercial facilities, these facilities will not be fully addressed. The focus of this paper is on private facilities.

## DEFINITIONS

In an effort to clarify the discussions below, the following definitions are provided:

Analysis of Record: One or more analytical values for a MACT regulated parameter or constituent which the facility O/O uses as the official concentration to demonstrating compliance with corresponding constituent feed rate limit. In the tradition approach, this would be the periodic reanalysis value. In the statistical approach, this would be the mean of several analyses.

MACT Parameter or Constituent: In this paper, parameter and constituent are used interchangeably to refer to ash,  $Cl_2/Cl^-$ , VM (Hg), SVM (Pb + Cd), and LVM (As + Be + Cr).

Regulatory Limit or Feed Rate Limit or Limit: These terms are used interchangeably in the discussions below to refer to a mass feed rate limit (g/hr, lb/hr) for each MACT constituent. The limits will be set during the Comprehensive Performance Test (CPT) based on constituent spiking and/or an Agency approved extrapolation plan. Since much of the discussion which follows involves decisions which must be made prior to the CPT, the use of the term "limit" refers in this context to the anticipated limit which will be established in the CPT. In some cases in the following discussion, reference is made to comparing an analysis value (ppm) to a limit (g/hr); it should be understood that the analysis value must be multiplied by the waste feed rate with appropriate unit conversions in order to make this comparison on a common units basis.

Feedstream versus Waste Stream: A feedstream is defined as the waste that is fed through a given feed device (burner, atomizer, lance, drum feed, bulk solids chute, etc.) into the combustor and is made up of one or more typically similar waste streams. At a typical private facility several organic waste streams are blended in a storage/blend/feed tank(s) and fed on a semi-continuous basis to the combustor. Some facilities have a sufficient quantity of organics contaminated water waste stream(s) to justify a second blend/atomizer system (see illustrative example below). The MACT statistical approach refers for feedstream(s) and not the individual waste streams.

## **EPA's REGULATORY INTENT**

One of the authors [Schofield] has had a number of phone discussions and correspondence with EPA Headquarters staff concerning the Agency's regulatory intent of this provision. The following (indented) text was drawn from a letter from Focus to the EPA in which Focus reiterated our understanding of EPA's intent concerning the §63.1208(b)(8)(i) provision and the degree of flexibility allowed in selecting the appropriate statistical method from the referenced data quality guidance document:

We have discussed this provision (see below) on several occasions and I believe I now understand what EPA intends.

§63.1208(b)(8)(i) states:

*For each feedstream, you must demonstrate that:  
(i) Each analyte [regulated parameter] is not present above the reported level [corresponding regulatory limit] at the 80% upper confidence limit around the mean; and ...*

(See *Guidance for Data Quality Assessment-Practical Methods for Data Analysis*, EPA QA/G-9, January 1998, EPA/600/R-96/084.) Note: The authors have inserted the bracketed comments to clarify somewhat ambiguous terms in the regulations.

Based upon my conversations with you and others at EPA Headquarters, I understand that you [EPA] intend this provision to provide a second, more flexible method of documenting compliance with metals, chlorine, and ash feed rate limits for hazardous waste combustion (HWC) units. While owner/operators (O/Os) of hazardous waste combustion facilities can continue demonstrating compliance by showing that every analysis is below its corresponding regulatory limit, O/Os may choose to develop the statistical approach authorized in this provision.

Implementing this provision would require:

- 1) collection of properly QA/QC'd parameter test results,
- 2) calculation of the mean and standard deviation for each parameter,
- 3) construction of the 80% upper confidence limit,
- 4) verification that all underlying statistical assumptions are met, and
- 5) demonstration that each parameter's 80% upper confidence interval is below its corresponding regulatory limit.

The degree of flexibility, which EPA intends in selecting the appropriate statistical method, is discussed in the following paragraphs.

*[Excerpt from letter continued...]*

Given that O/Os have collected waste analysis data for years and the statistical approach involved is very basic (if the underlying statistical assumptions involved are met), this would appear to be a relatively easy provision to implement. However, when I used the Quest™ software (provided in the above referenced Guidance) to establish the upper confidence interval, I found that none of the eight datasets I used satisfied the distribution assumptions for any of the tests for the mean provided in the Guidance.

In the Guidance, each statistical approach is discussed in terms of how it can be used and the underlying assumptions upon which it is based. If the assumptions for one method are not met, the Guidance suggests one or more other methods with less stringent assumptions. For example, if the normality assumption is not met for a t-Test, Guidance suggests the nonparametric Wilcoxon Signed Rank Test, which requires only a symmetrical distribution of the data (see Limitations and

Robustness, Page 3.2-2 of the Guidance). In Section 3.2.1.2 which discusses the Wilcoxon Signed Rank Test, Guidance says that "for small sample sizes, if the data are not approximately symmetric and not normally distributed, this Guidance recommends changing the population parameter to the median and applying a different statistical test (Section 3.2.3)". Section 3.2.3 covers tests for a median and says that the Wilcoxon Signed Rank Test for the median is the preferred test because the median test is powerful and is less sensitive to extreme values and nondetects than any of the tests for the mean. Nondetects are very common when testing waste for the regulated parameters; extreme values are not uncommon.

Based on the results with these first datasets, it appears that reasonable flexibility is needed to select the best statistical method available (i.e., a powerful method for which the data assumptions are met.) For the datasets analyzed, this would mean that the affected O/O would need the regulatory flexibility to select an appropriate test for the median when the regulations specify the mean (an almost identical term, in most cases).

EPA's representative responded:

*"From my review of your memorandum of September 8, 2000, it appears to me that your interpretation of the regulatory intent falls within the flexibility allowed in the Agency's G-9 Guidance Document (Guidance for Data Quality Assessment-Practical Methods for Data Analysis)."*

The authors draw two conclusions from this exchange:

1. The statistical 80% UCL approach seemingly prescribed in the HWC MACT is intended as a second or alternative method to demonstrating compliance with feed rate limits. The existing or traditional approach (which requires periodic [typically yearly] re-analysis of the feeds and the use of these constituent analytical values to demonstrate compliance until the next analyses are available) is still available to the O/O.
2. A fair degree of flexibility is provided in the referenced guidance in selecting the most appropriate statistical method for a given site-specific case should the O/O elect to use the statistical approach.

The reader should note that at the time of this paper submission, one critical issue had not been addressed. From an environmental protection perspective the total feed rates of metals, ash,  $Cl_2/Cl^-$  into the incinerator is the only issue of concern. A more representative private incinerator might have two liquid waste streams, which are simultaneously and continuously fed to the incinerator. Both could have data with which an O/O could demonstrate an 80% UCL, which is well below the corresponding regulatory limit yet the total feed rate would exceed the limit. The authors believe that EPA intends that the 80% UCL of the total feeds should be used. The example case provided later in the paper is based on the 80% UCL of the total feeds. We have assumed that it is obvious that if the 80% UCL of the total feeds is less than the corresponding regulatory limit then the 80% UCL of the individual streams will also be less than the regulatory limit. [Phone discussions with a senior EPA headquarters staff member, immediately prior to the submission of this paper, confirmed that the Agency was primarily interested in the total feed rate of a MACT constituent to the HWC. However, he was unable to provide a written statement to this effect.]

#### **HOW TO SELECT WHICH FEED RATE COMPLIANCE DEMONSTRATION METHOD TO USE AT A GIVEN FACILITY – GENERAL GUIDELINES**

In an effort to assist the reader in selecting which of these two approaches to use in demonstrating compliance with their feedstream limits, the authors have prepared three cases, which generally describe the facilities with which we are familiar. Case 1 is divided into two subcases, A and B. These should be considered as general guidelines in making your selection. Also, note that a given facility may choose one

approach for some parameters (for example, PM/ash,  $\text{Cl}_2/\text{Cl}^-$ , and VM [Hg]) and the other approach for the remaining parameters (in this example, SVM [Pb, Cd] and LVM [As, Be, Cr]).

### **CASES 1A AND 1B USE THE TRADITIONAL PERIODIC REANALYSIS APPROACH**

#### **CASE 1A** Most private (non-complex) facilities with low MACT constituent concentrations

In this case, the total feed rate for the constituent of interest has been shown via wastestream analyses to be much lower than the corresponding regulatory limit. The O/O can see from reviewing the level and scatter in feedstream analyses that there is almost no chance that a future analytical result would cause an exceedance of a constituent feed rate limit even at the maximum permitted waste feed rate. In this case, the traditional periodic reanalysis method would ensure compliance and is much simpler to administer. Most parameters at most private facilities would fall into this case.

#### **CASE 1B** Commercial facilities and complex private facilities.

Typically these facilities must manage many different wastestreams (>1,000 wastestreams is not unusual) which frequently include containerized and bulk wastes. As a result, these facilities usually have at least fairly extensive storage/blend/feed tank systems and fairly sophisticated blending procedures to ensure compliance with constituent feed rate limits. Because of this intentional manipulation of waste blending to achieve an intended concentration result, the concept of random, independent statistical sampling is undermined. For this reason the authors believe that the only practical method of demonstrating compliance with feed rate limits in these complex facilities is the periodic reanalysis approach.

#### **CASE 2** Private facilities with moderately low parameter concentrations and/or fairly tightly bunched analytical results.

These facilities have a practical risk of some future high waste constituent analyses that would result in exceeding a constituent feed rate limit at maximum waste feed rates. If sufficient excess capacity were available to restrict the wastestream feed rates without undue operating difficulties, the traditional reanalysis approach would be simpler to administer. However, if insufficient excess capacity is available, then the Feedstream Analysis Plan (FAP) should be prepared to use the statistical approach.

#### **CASE 3** Private facilities with at least one constituent with widely scattered analyses and/or analyses near or even above the regulatory limit. Use the statistical approach (and/or restrict waste feed rate).

These facilities have a very real possibility that some future analyses will result in exceeding one or more constituent feed rate limits at maximum wastestream feed rates. The O/O should use the statistical approach and/or restrict waste feed rates.

### **HOW MANY SAMPLES WILL I NEED?**

One of the most frequently asked questions in discussions on complying with the HWC MACT feed rate limits is "How many samples should I have in order to select the compliance approach (traditional reanalysis versus statistical analysis) and initiate the statistical approach should I make that selection? Analytical costs are high but must be balanced against costs associated with not fully characterizing your operation (i.e., non-compliance, operating restrictions). There is no set answer because each facility will have differences (1) between their average constituent concentrations and corresponding limits, (2) the degree of scatter in the data, (3) incineration capacity versus ongoing needs, (4) storage capacity, etc. We have provided general guidelines in the following paragraphs. The number of samples mentioned should be viewed as bare minimums. More information is always better but a point will be reached where additional samples have minimum incremental benefit. Where this point of diminishing returns occurs will vary from facility to facility. Most facilities will already have larger datasets than the minimums suggested. If intermittent production processes contribute to the waste feeds, the sampling should include a proportionate number of samples from the feedstream when it contains these wastestreams. This

precaution applies to both the initial datasets and data collected during normal operations. This data should be validated. Any data that does not meet MACT QA requirements should be removed from the dataset and replaced with new data if necessary to meet the minimums. Then analyze the dataset to obtain a feel for which of the cases discussed above best describes your facility. In many cases it will be unclear based on a minimum dataset and additional analyses should be obtained.

Based on the experience of the authors, a minimum of six and preferably ten properly validated results should be in your dataset before attempting to make these decisions. If the decisions are not clear with the initial dataset (very likely), then additional samples and other site-specific information may be needed.

(Precaution: All statistical methods applicable to these decisions assume a "stationary" or non-changing underlying statistical distribution. If a facility believes based on process knowledge and/or statistical results that the constituent levels or variability has changed, especially if it results in increased analytical values, a new dataset should be prepared.)

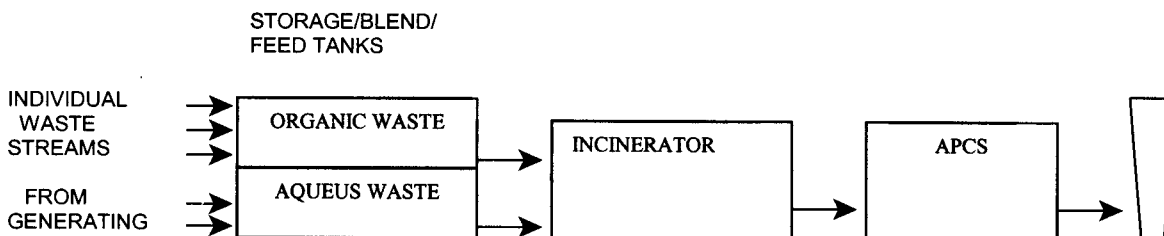
In reviewing the datasets, a preliminary feel can be obtained by observing the average, the degree of data scatter, and position of the mean compared to the corresponding regulatory limit. After this preliminary review and deciding that your facility might fit cases 2 or 3, analyze the data statistically beginning with the appropriate t- statistic using the mean and standard deviation to construct the 80% UCL. (The above-mentioned Quest© software provided in the reference guidance provides built-in checks for normality and other distribution characteristics on which each statistical methods are based. The Guidance also provides the underlying assumptions for a number of standard statistical methods. Many other methods are available in the statistical literature and professional statistical software packages. If your data meets all the assumptions underlying the normal distribution, then calculate the 80% UCL using the appropriate t- statistic. In most cases other statistical methods must be used. In every case you must confirm that the underlying assumptions of the method you select have been met.)

Once you have selected the best statistical method for which all of the underlying assumptions are met, analyze your dataset using this method and calculate the 80% UCL, based on total mass feed rate of the regulated parameter, and compare it to the corresponding regulatory limit. If the 80% UCL were far from the corresponding regulatory limit, then a relatively long period (1 year) for reanalysis would be appropriate. If the 80% UCL is near the regulatory limit, more frequent reanalysis would be appropriate.

No broad, fixed recommendation concerning reanalysis frequency is practical since this will depend on policies of the O/O's organization, agency policy and the margin between the 80% UCL and the regulatory limit.

### **AN ILLUSTRATIVE EXAMPLE**

In order to illustrate many of the points made above, the following real world example is provided. Details concerning flow rates, limits, etc are not provided to protect the client's interests. In this example, two types of waste (aqueous and organic) are fed simultaneously, each carrying its own contribution of feed rate-limited constituents. These wastestreams are comprised of many individual wastestreams produced in different, intermittently operated units. The waste is fed to the aqueous or organic storage/feed tanks, depending upon whether they are primarily of aqueous or organic in composition. The two streams have different maximum feed rate limits.





Between 14 and 28 analyses were available for the MACT regulated feed rate-limited constituents. Some MACT parameters were not analyzed in some of the 28 samples. The LVM and SVM totals were calculated when analyses for all the individual metals in the SVM and LVM categories were available from the same sample. A table of the VM (Hg), SVM, LVM, Cl, and Ash concentration values was prepared for each waste type i.e., organic and aqueous. (See Table 1) These numbers were converted to the constituent feed rate, Lb/Hr, in each case using the following equation:

$$W_{ij} = (FRO [Wi]^o_j + FRA [Wi]^A_j) / 1,000,000$$

Where:

- $W_{ij}$  = the maximum mass flow rate of constituent i based on sample j, Lb/Hr
- $[Wi]^o_j$  = Concentration of parameter i from sample j in the organic stream (similarly for the aqueous stream A  $[Wi]^A_j$ ), ppm
- FRO = the maximum feed rate for the organic stream (similarly for the aqueous stream, FRA), Lb/Hr

For ash, the above equation was modified to divide by 100 since the ash concentrations were expressed as percent instead of ppm.

More than 50 % of the individual  $W_{ij}$  values were nondetects. The resulting  $W_{ij}$  values were evaluated by the statistical methods provided in the Quest© software. The underlying assumptions were not met for any statistical method for the mean provided by Quest©. However, the most powerful method for which all assumptions were met was the Wilcoxon Signed Rank Test for the median that in this case uses the regulatory limit to determine the "sign" of a value; plus 1 for an exceedance and -1 for a non-exceedance. Correspondence with EPA headquarters confirmed that the use of the median was within the regulatory flexibility intended by the Guidance.

Analysis of the data indicated no exceedance of the limit for any of the parameters. In this case proceeding with the calculation of the 80% UCL was not completed since this facility clearly falls within case 1A described above. Focus recommended to this facility that they continue to use the traditional re-analysis method for demonstrating compliance with their MACT constituent feed rate limits.

### Conclusions

1. The O/O of a facility may chose to continue the traditional periodic reanalysis or instead to choose the HWC MACT 80% UCL statistical approach to documenting compliance with MACT constituent feed rate limits.
2. EPA intends for the O/O to have reasonable flexibility in selecting the most appropriate statistical method to establish the 80% UCL should the O/O elect to implement the MACT statistical approach.
3. At least two issues remain unresolved at the time of this paper's submission:
  - a) Does EPA intend for O/O to establish the 80% UCL for the total constituent feed to an incinerator, which would be consistent with environmental protections but contrary to the regulations wording of the §63.1208(b)(8) provision which requires the 80% UCL for each individual feedstream (but not the total) must be below the regulatory limit. (Based on last minute phone discussions, we believe that EPA does intend the O/O to base the 80% UCL on the total constituent feed rate.)

- b) If an O/O elects to continue using the traditional periodic reanalysis feed limit compliance demonstration approach, must the O/O also collect and statistically analyze constituent concentration data for each individual feedstream as prescribed in the MACT 80% UCL approach.
4. Even when all regulatory interpretation issues are resolved, implementation probably will require a significant amount of time and resources.